SENSORS RESEARCH AND TECHNOLOGY

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TECHNOLOGY FOR FUTURE NASA MISSIONS

AN AIAA/OAST CONFERENCE
ON CSTI AND PATHFINDER

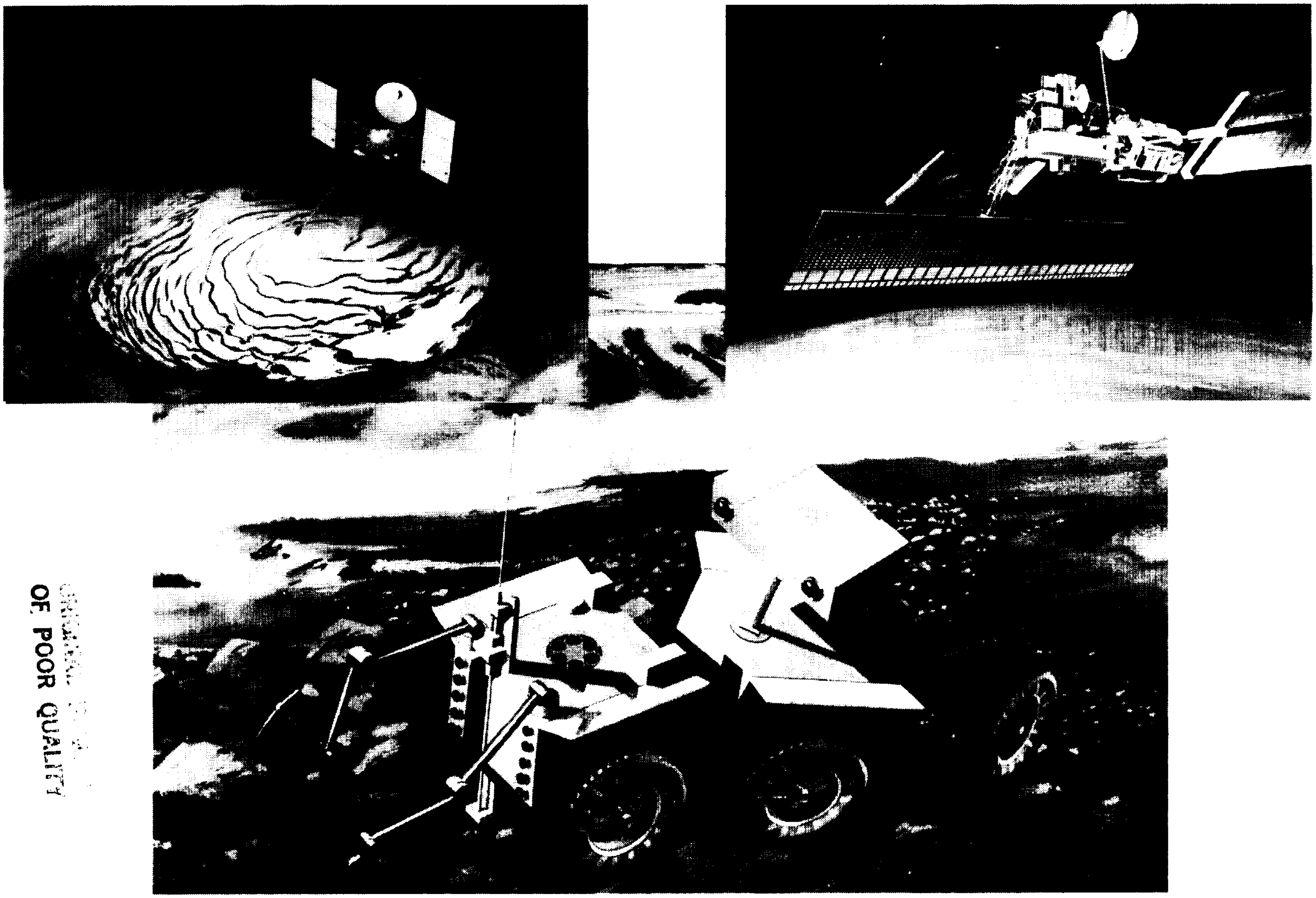
12 - 13 SEPTEMBER, 1988

WASHINGTON D.C.

SENSING TECHNIQUES FOR SPACE SCIENCE

PASSIVE REMOTE SENSING

ACTIVE REMOTE SENSING

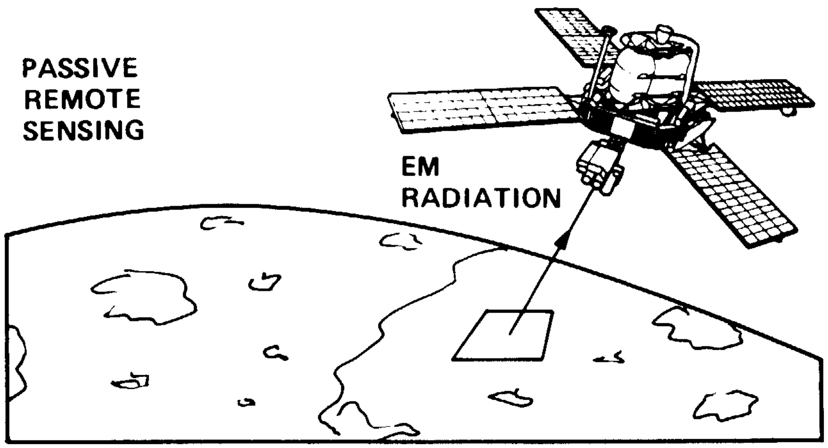


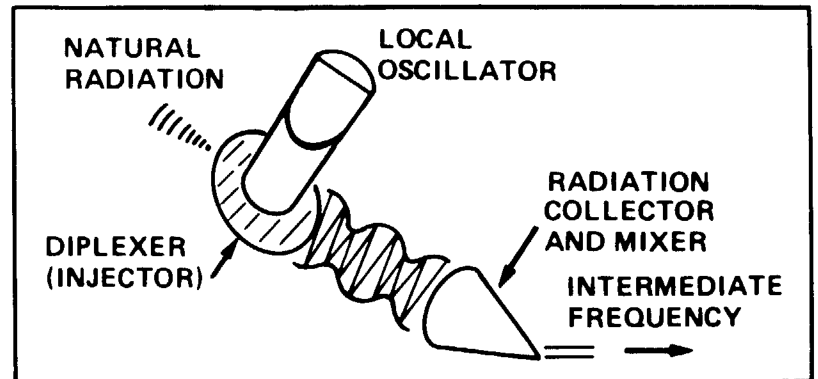
IN-SITU SENSING

SENSOR RESEARCH AND TECHNOLOGY
GOALS AND APPROACH

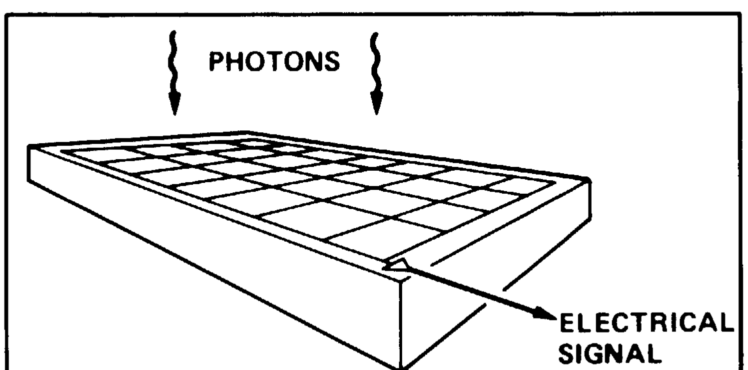
- DEVELOP ENABLING AND ENHANCING SENSOR TECHNOLOGY FOR NASA SPACE SCIENCE MISSIONS
- EMPHASIZE DEVICE AND COMPONENT TECHNOLOGIES WITH MEDIUM-TERM AND LONG RANGE IMPACT
- PROGRAM ELEMENTS ARE
  - PASSIVE REMOTE SENSING TECHNOLOGY
    - ⇨ COHERENT (HETERODYNE) SENSING
    - ⇨ NON-COHERENT (DIRECT) SENSING
  - ACTIVE SENSING
  - SPACE COOLER TECHNOLOGY

PASSIVE REMOTE SENSING: TECHNIQUES AND APPLICATIONS

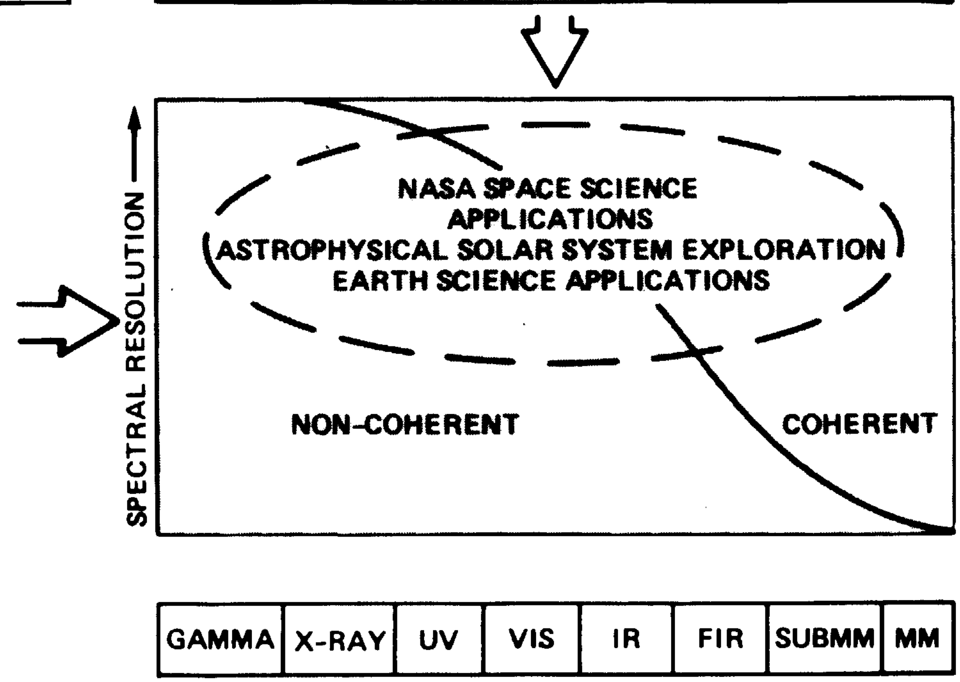




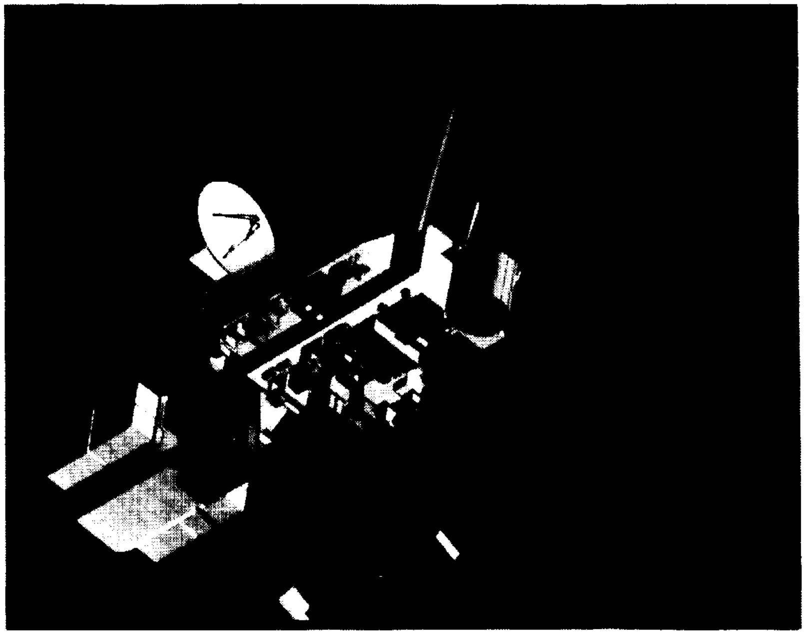
COHERENT (HETERODYNE) SENSING



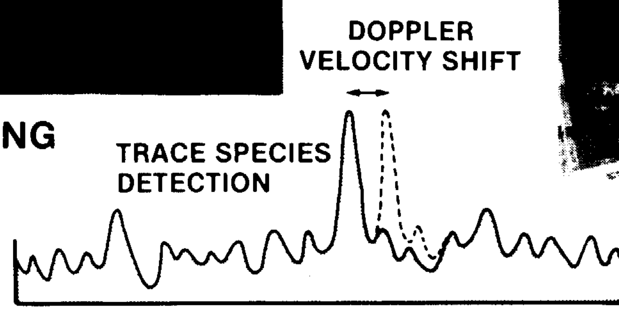
NON-COHERENT (DIRECT) SENSING



NASA SUBMILLIMETER COHERENT SENSING



EARTH OBSERVING SYSTEM



HIGH RESOLUTION SPECTRUM

LARGE DEPLOYABLE REFLECTOR

APPLICATIONS

- MEASURE TRACE SPECIES IN ATMOSPHERES OF EARTH AND PLANETS AND ASTROPHYSICAL GASES AND PLASMAS
- MAP DISTRIBUTIONS OF TEMPERATURES AND VELOCITIES

COHERENT SENSOR RESEARCH
SUBMILLIMETER MIXERS

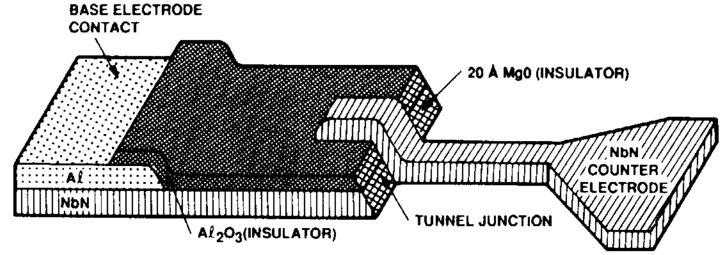
REQUIREMENTS

- QUANTUM EFFICIENCY
  > 10%, 300 - 3000 GHz
- RUGGED PLANAR TECHNOLOGY SUITED TO ARRAYS
- LOW LOCAL OSCILLATOR POWER

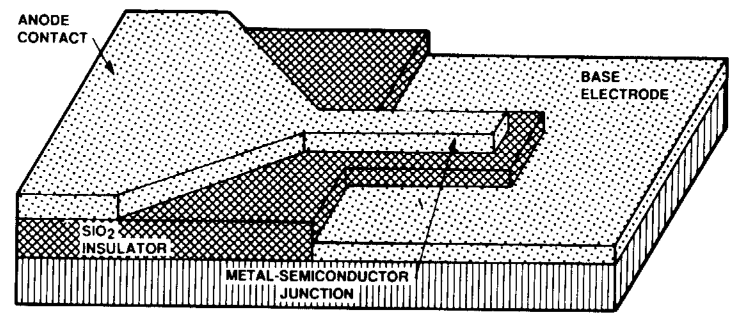
APPROACH

- DEVELOP THREE TECHNOLOGIES TO COVER SUBMILLIMETER SPECTRAL RANGE AND SUITABLE FOR DIFFERENT OPERATING TEMPERATURES

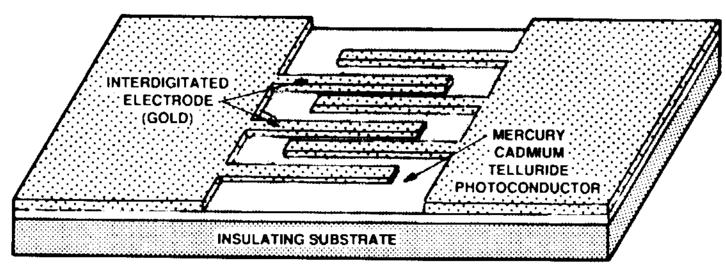
SIS TUNNEL JUNCTION



SCHOTTKY BARRIER DIODE IN Ga As



INTERDIGITATED ELECTRODE PHOTOCONDUCTIVE MIXER



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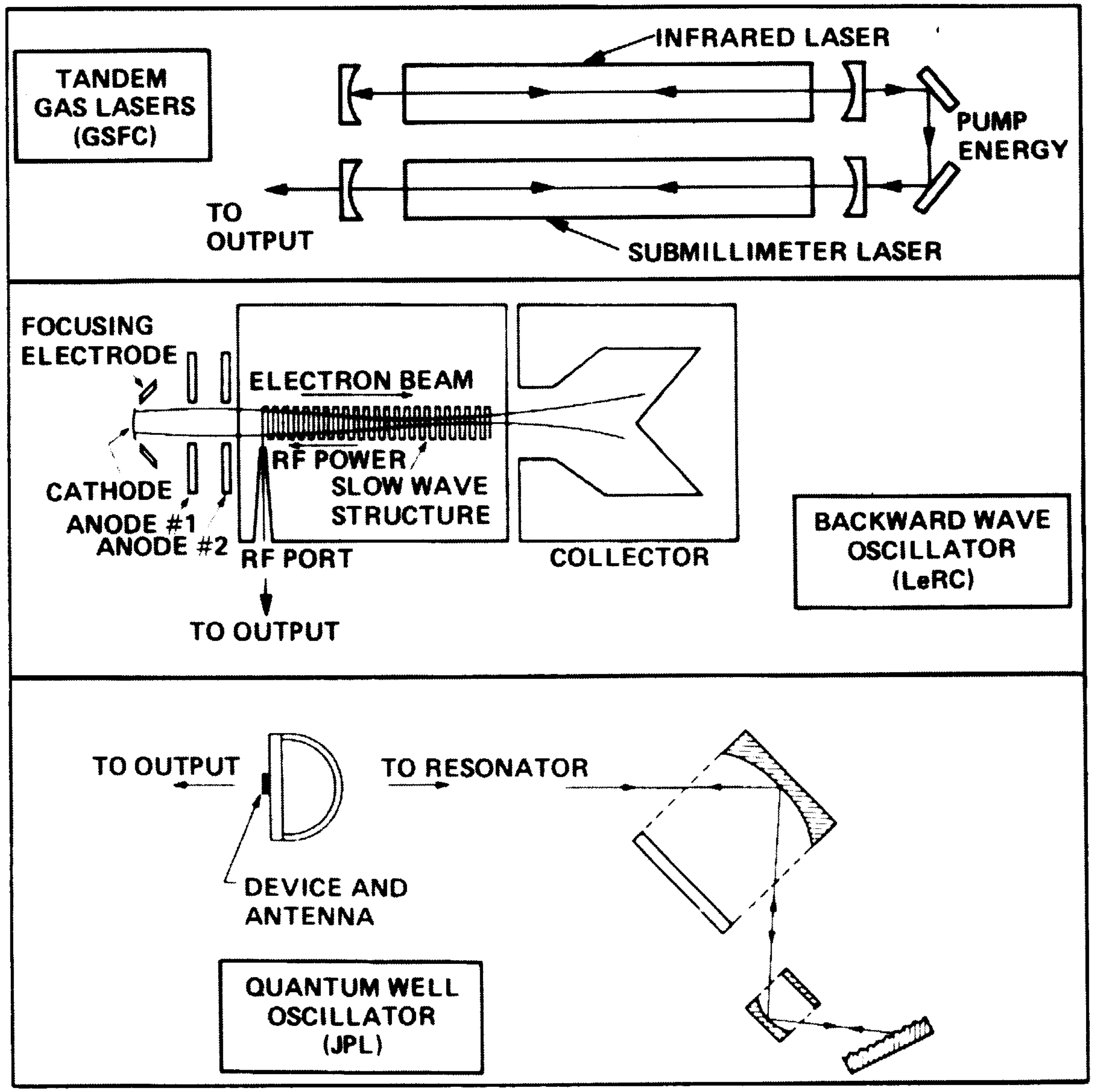
COHERENT SENSOR RESEARCH
SUBMILLIMETER LOCAL OSCILLATOR SOURCES

REQUIREMENTS

- LOW POWER AND MASS
- COMPACT AND RUGGED
- TUNEABLE 300-3000 GHz
- SPECTRALLY PURE WITH 1μ W - 1mW OUTPUT

APPROACH

- DEVELOP THREE TECHNOLOGIES TO PROOF-OF-CONCEPT
- SELECT TECHNOLOGY FOR SPACE QUALIFIABLE PROTOTYPE IN 1988



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COHERENT SENSOR RESEARCH
ACCOMPLISHMENTS

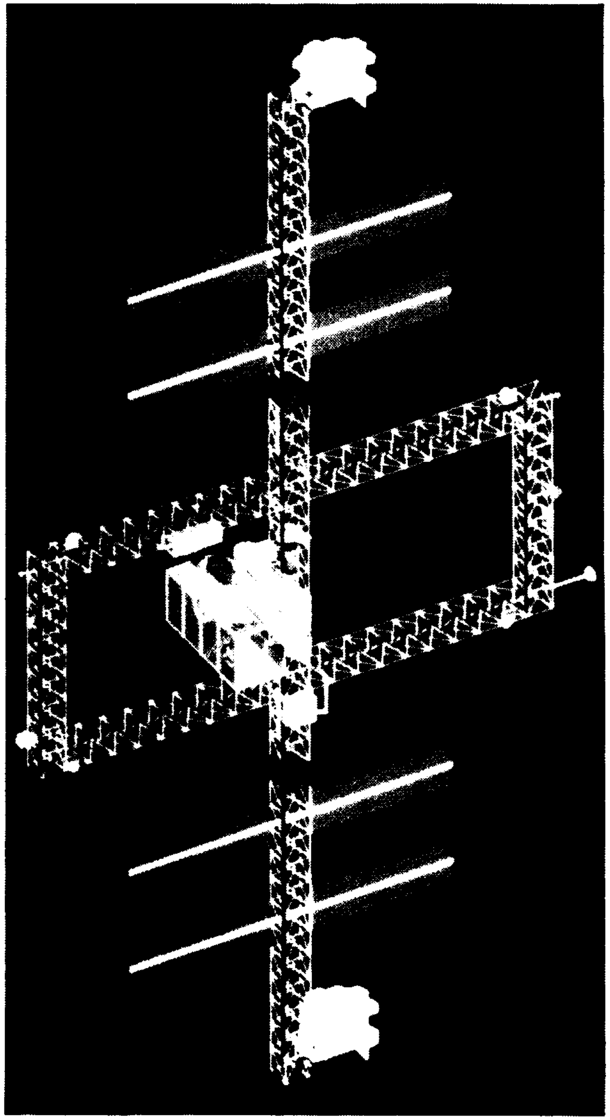
MIXERS

- SIS TUNNEL JUNCTIONS
  - HIGHEST FREQUENCY EVER REPORTED IN LEAD JUNCTIONS (600 GHz) - FY 86
  - FIRST DEMONSTRATION OF NbN MIXER - FY 88
- IDEPC/MCT DEVICES
  - ACHIEVED 2% QE AT 10 Thz - FY 87
  - DESIGNED AND FABRICATED DEVICE FOR 3 THz OPERATION - FY 88

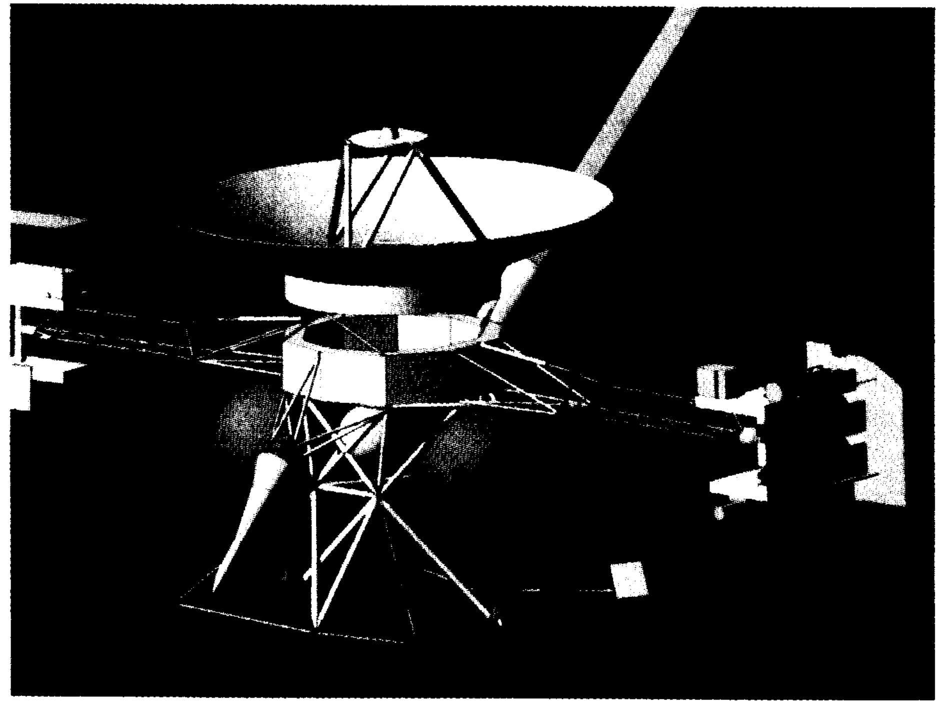
LOCAL OSCILLATORS

- ALL SOLID STATE OSCILLATORS
  - DEMONSTRATED HIGHEST FREQUENCY FUNDAMENTAL SOLID STATE OSCILLATOR (6 μW @ 420 GHz)
  - DEMONSTRATED HIGH HARMONIC MULTIPLICATION
- BACKWARD WAVE OSCILLATOR
  - FIRST DEMONSTRATION OF OSCILLATION AT 200 GHz

NASA NON-COHERENT SENSORS



SPACE STATION



MARINER MARK-II SPACECRAFT

APPLICATIONS

- MULTISPECTRAL IMAGING OF THE SURFACES OF EARTH AND PLANETS
- MOISTURE AND TEMPERATURE SOUNDING OF ATMOSPHERES
- IMAGING AND SPECTROSCOPY OF ASTROPHYSICAL OBJECTS

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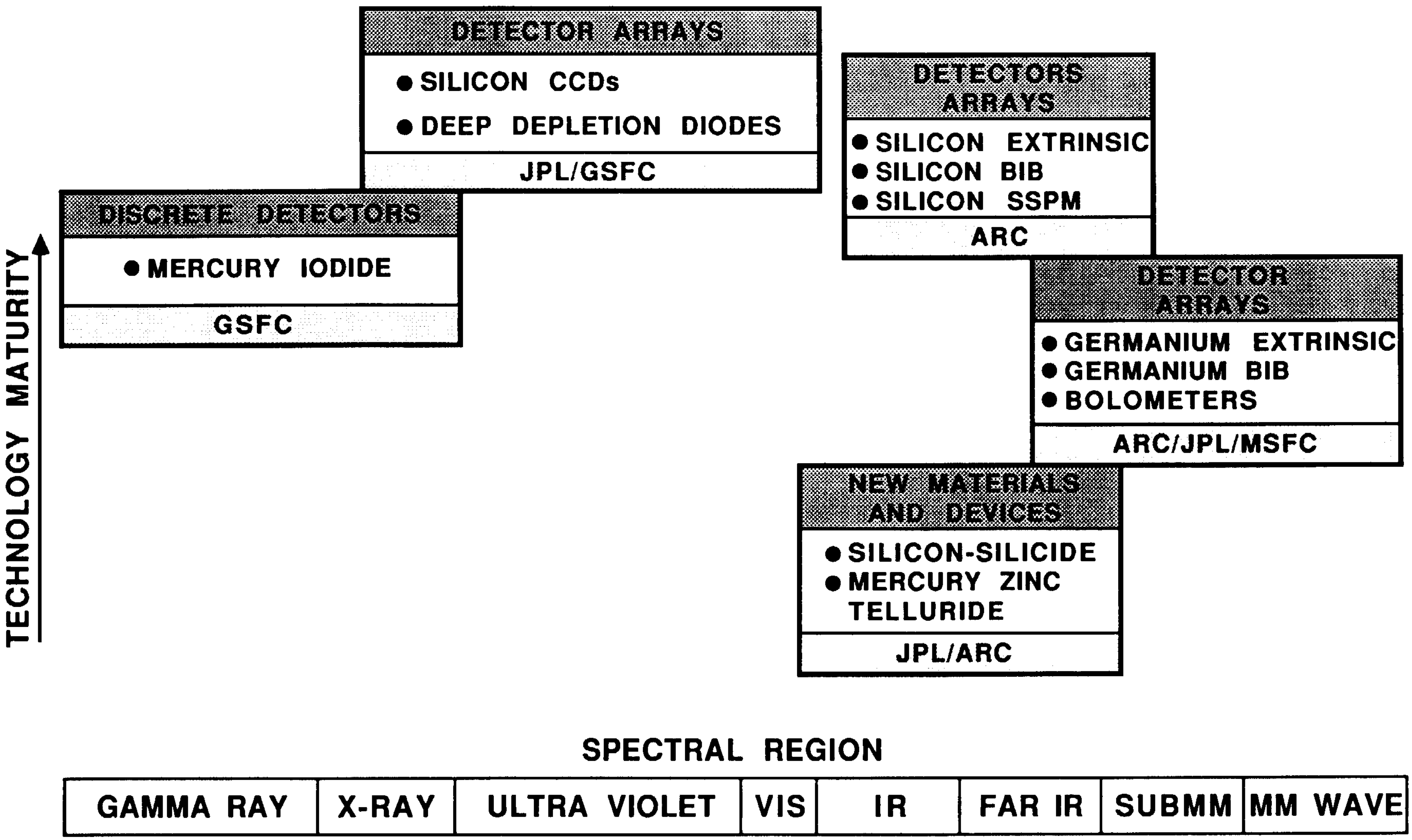
NON-COHERENT SENSORS
KEY TECHNOLOGIES



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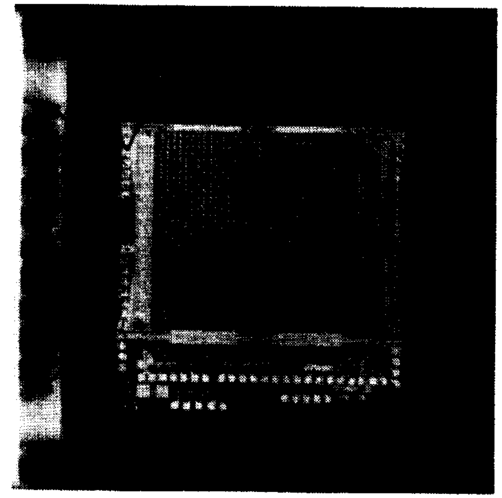
NON-COHERENT SENSORS
INFRARED TO MILLIMETER WAVE TECHNOLOGY

REQUIREMENTS

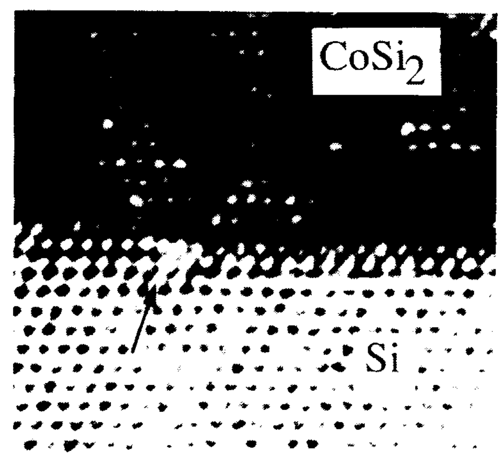
- DIVERGENT REQUIREMENTS DEPENDING ON
  - ⇒ SPECTRAL REGION
  - ⇒ SPECTRAL APPLICATION

APPROACH

- ADAPT MATURING DoD-SPONSORED EXTRINSIC-SILICON TECHNOLOGY TO MEET NASA NEEDS FOR FAR IR
- DEVELOP NEW GERMANIUM-BASED TECHNOLOGY FOR SUBMILLIMETER
- DEVELOP ENABLING MATERIALS AND DEVICE TECHNOLOGIES TO MEET LONG RANGE NEEDS FOR LARGE ARRAYS AND HIGHER TEMPERATURE OPERATION



32 x 32 DETECTOR AND MULTIPLEXER



ULTRA HIGH MAGNIFICATION VIEW OF CROSS SECTION OF SILICON-COBALT SILICIDE DETECTOR MATERIAL

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NON-COHERENT SENSORS
GAMMA RAY/X-RAY/ULTRAVIOLET

REQUIREMENTS

- HIGH SENSITIVITY
- SPECTRAL RESOLUTION
- MINIMAL COOLING
- DETECTOR ARRAYS WHERE PRACTICAL FROM 10 TO 10^6 ELEMENTS

APPROACH

- TRANSITION CCD TECHNOLOGY TO SPACE SCIENCE APPLICATIONS
- DEVELOP MERCURY IODIDE TO MEET NEEDS WHERE SENSOR COOLING IS IMPRACTICAL

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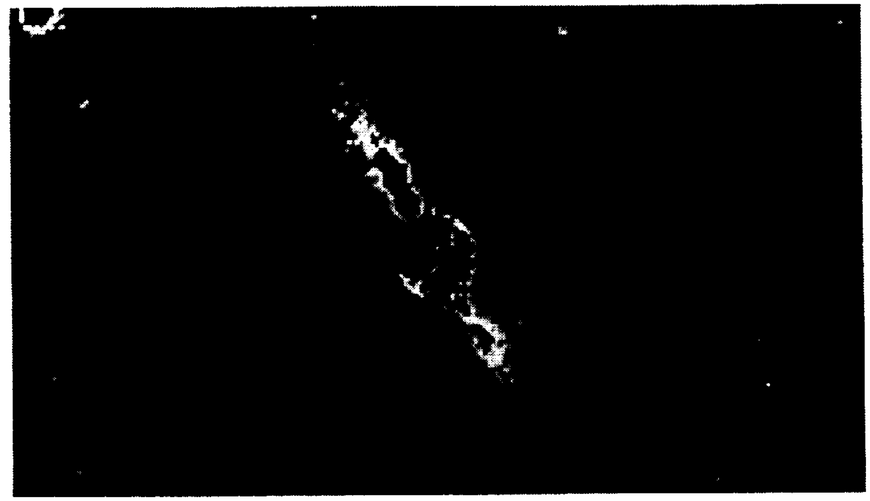
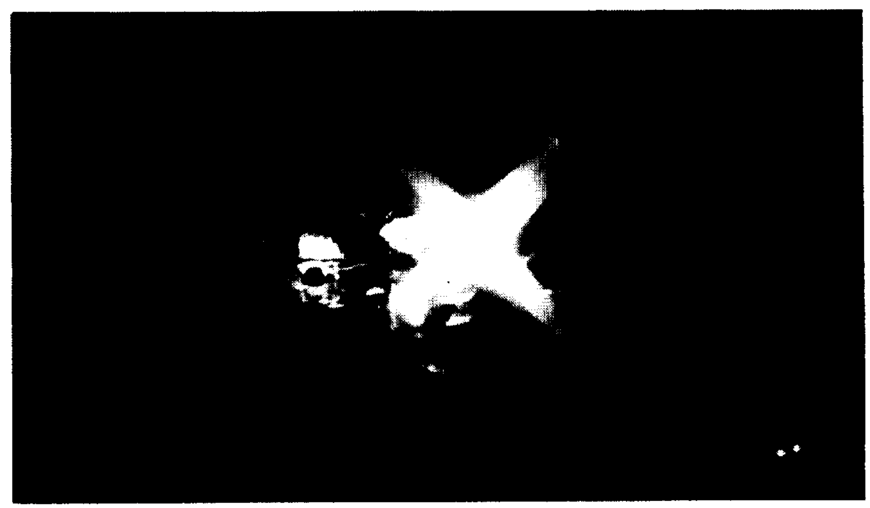


CCD IMAGE OF BETA PICTORIS



MERCURIC IODIDE CRYSTAL FOR GAMMA RAY DETECTION

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NON-COHERENT SENSORS
ACCOMPLISHMENTS

GAMMA RAY TO ULTRAVIOLET

CCD TECHNOLOGY

- TRANSFERRED TECHNOLOGY TO APPLICATIONS IN SPACE TELESCOPE, GALILEO AND AXAF PROGRAMS

MERCURY IODIDE

- DEMONSTRATED 7% SPECTRAL RESOLUTION FOR 0.661 KeV GAMMA RAYS AT ROOM TEMPERATURE

INFRARED TO MILLIMETER WAVE

- DEMONSTRATED ADVANCED DETECTOR ARRAY TECHNOLOGY BASED ON SILICON (DARK CURRENT $<10\ e^-/sec$, NOISE $<50\ e^-$)

- PIONEERING DEVELOPMENT OF GERMANIUM BIB TECHNOLOGY FOR SUBMILLIMETER

- DEMONSTRATED EXTENSION FROM 3.5 TO 5.0 μm IN COBALT SILICIDE INFRARED DETECTOR SPECTRAL RESPONSE CUTOFF

ACTIVE REMOTE SENSING

OBJECTIVES

- MAP THE DISTRIBUTION OF WIND VELOCITY, WATER VAPOR AND TRACE GASES IN THE ATMOSPHERE OF THE EARTH

TECHNOLOGY NEEDS

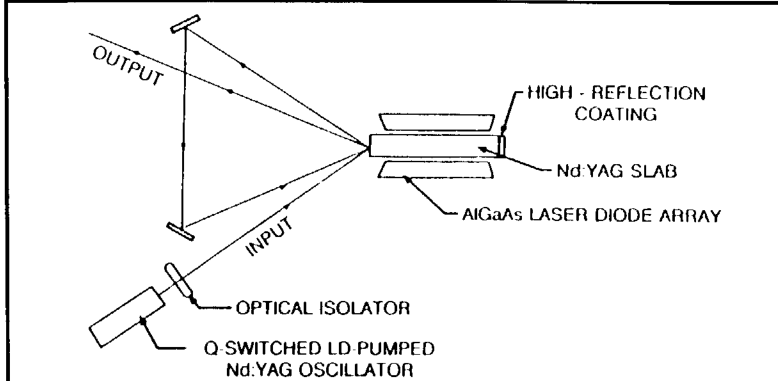
- SOLID STATE LASERS WITH HIGH PULSE POWER AND FREQUENCY
- CARBON DIOXIDE LASERS FOR MEASUREMENT OF DOPPLER SHIFTS OF SCATTERED RADIATION

ACTIVE REMOTE SENSING
SOLID STATE LASER DEVELOPMENT

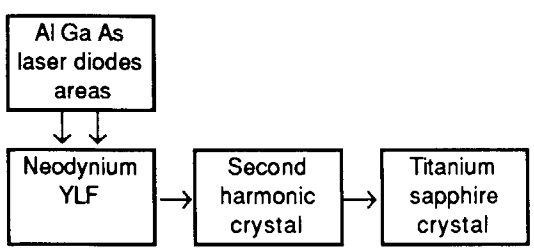
REQUIREMENTS:

- PULSE ENERGIES (~1 JOULE)
- REPETITION RATE (10 Hz)
- EFFICIENCY (>5%)
- SPECTRAL RANGE (1μm-20μm)
- SPECTRALLY TUNABLE

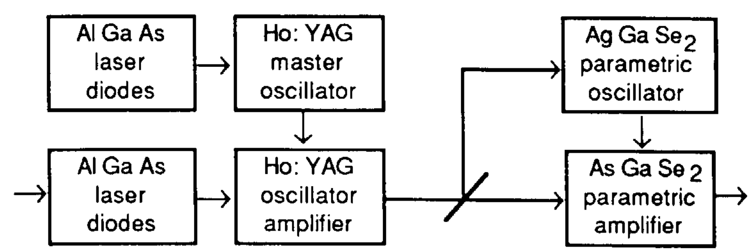
LASER DIODE-PUMPED NEODYNIUM:YAG LASER



TITANIUM: SAPPHIRE LASER



OPTICAL PARAMETRIC OSCILLATOR



ACTIVE SENSOR RESEARCH
ACCOMPLISHMENTS

CO_2 LASERS

- DEVELOPED CATALYST TECHNOLOGY FOR LONG LIFE TIME APPLICATIONS. PLANNED FOR USE IN LAWS PROGRAM

SOLID STATE LASERS

- PIONEERED DEVELOPMENT OF TITANIUM SAPPHIRE TECHNOLOGY

- CONCEIVED NEW APPROACHED FOR ACTIVE SENSING IN MID INFRA RED

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SPACE COOLER TECHNOLOGY
PROGRAM GOALS

NEEDS:

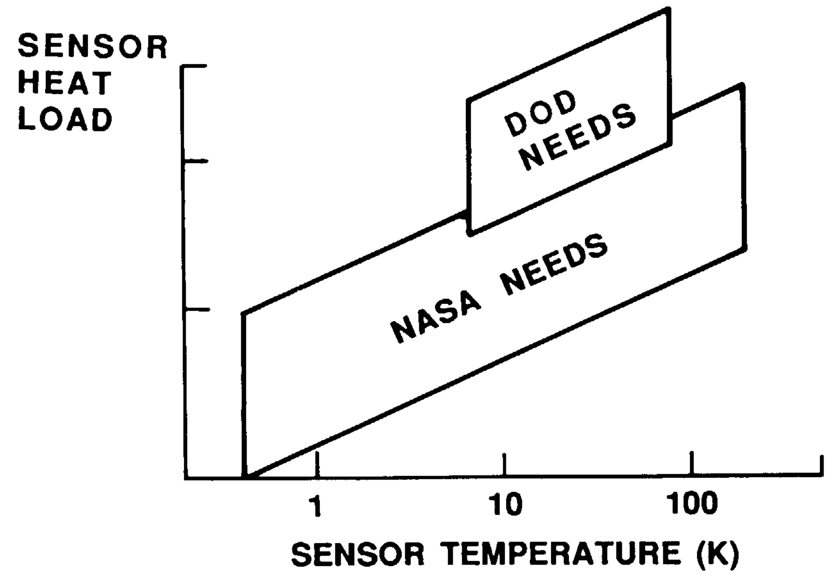
- SENSOR COOLING FROM 150K TO SUBKELVIN (<1K) TEMPERATURE

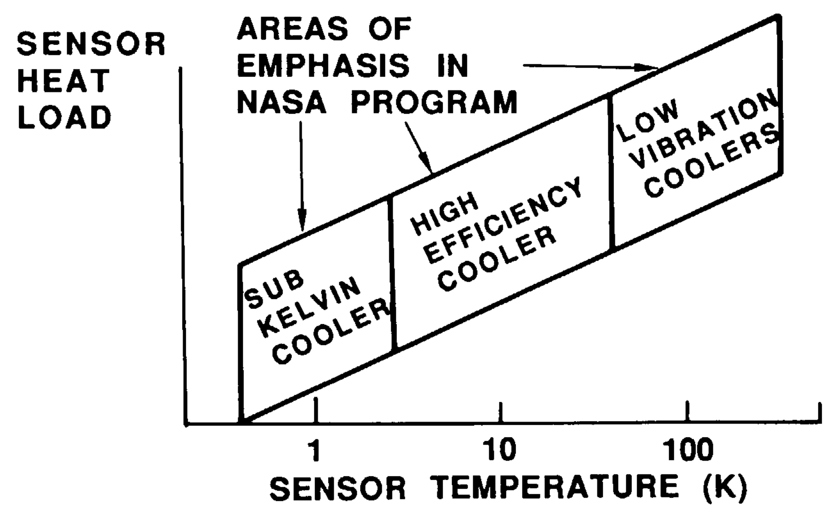
CONSTRAINTS:

- POWER AND MASS BUDGETS OF SPACECRAFT EXTREMELY TIGHT
- LONG LIFETIME AND RELIABILITY PARAMOUNT
- ULTRA LOW VIBRATION AND EMI ARE CRITICAL FOR MANY APPLICATIONS

APPROACH:

- STRESS ADVANCES IN COMPONENT TECHNOLOGY WITH ORDER-OF-MAGNITUDE PERFORMANCE IMPACT
- EXPLORE INNOVATIVE SYSTEM CONCEPTS FOR SOLVING PROBLEMS IMPOSED BY SPACE ENVIRONMENT





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SPACE COOLER TECHNOLOGY
LOW VIBRATION COOLER (65-80K)

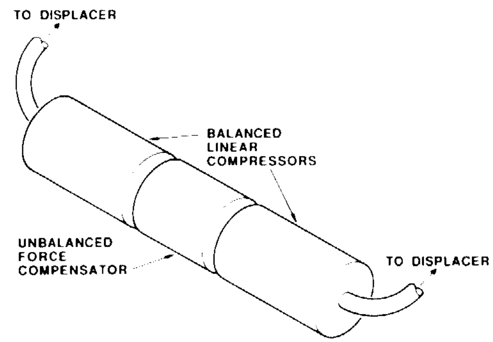
REQUIREMENTS

- COOLING TO THE RANGE FROM 10 - 150K
- LOADS UP TO 5W
- ULTRA LOW VIBRATION
- HIGH EFFICIENCY, POWER LESS THAN 200W
- LIFE TIMES > 5 YEARS

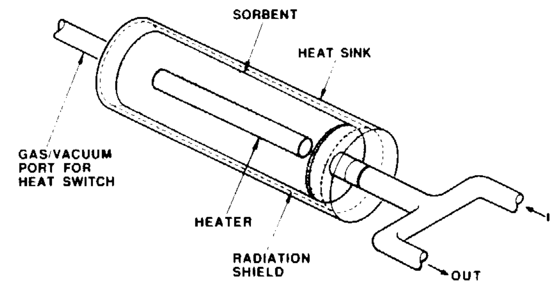
APPROACH

- DEVELOP KEY COMPONENTS OF SYSTEMS WITH POTENTIAL OF MEETING THESE REQUIREMENTS

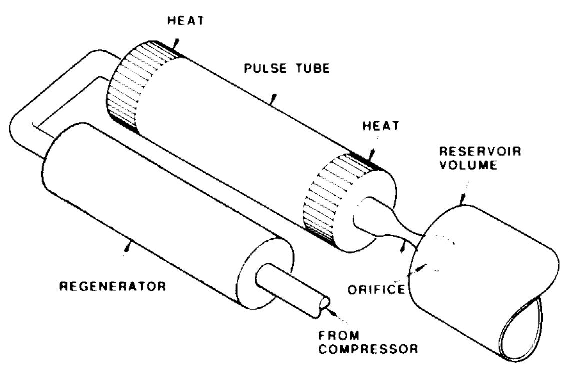
LOW VIBRATION MECHANICAL COMPRESSOR



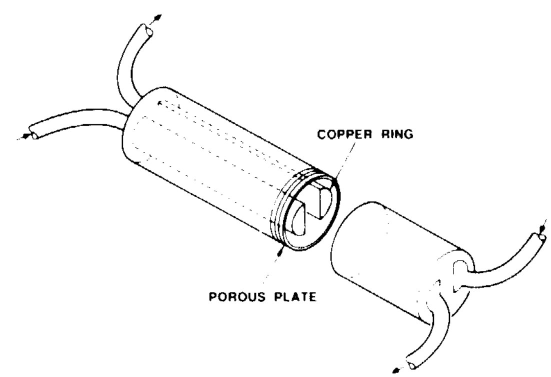
SORPTION COMPRESSOR



PULSE TUBE REFRIGERATION



RECUPERATIVE HEAT EXCHANGER



NASA SPACE CRYOCOOLER TECHNOLOGY

SEPARATION OF LIQUID HELIUM (^3He AND ^4He) AND VAPOR PHASE IN ZERO-G

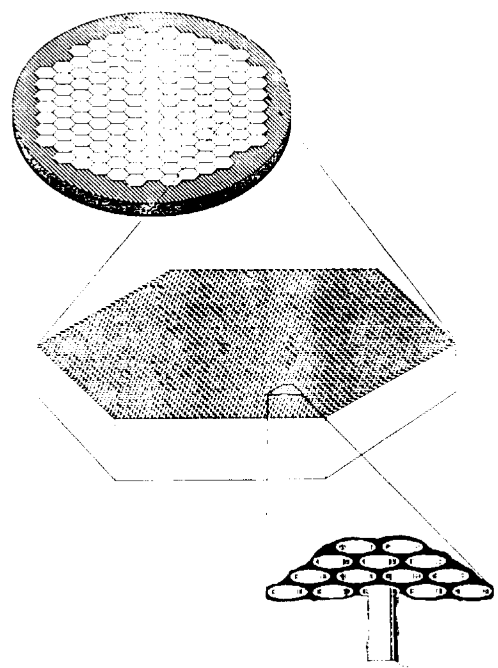
REQUIREMENTS:

- EFFICIENT SEPARATION OF LIQUID AND GAS PHASES FOR
  - → ^3He–^4He DILUTION REFRIGERATION
  - → ON ORBIT TRANSFER OF LIQUID HELIUM

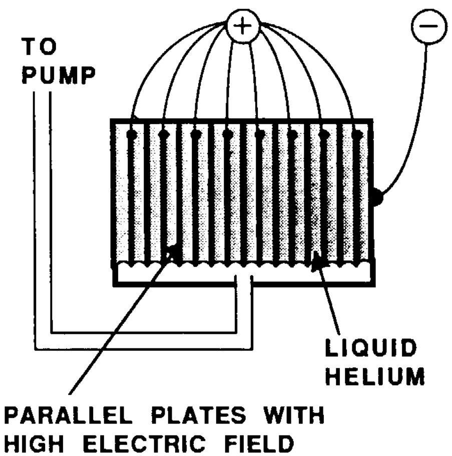
APPROACH:

- INVESTIGATE AND CHARACTERIZE NON-GRAVITATIONAL PHASE SEPARATION PHENOMENA
- FABRICATE AND DEMONSTRATE DEVICES FOR ACHIEVING PHASE SEPARATION FOR REFRIGERATOR AND CRYOGEN TRANSFER APPLICATIONS

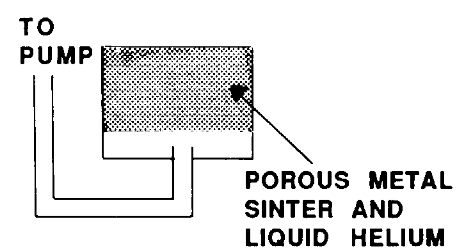
HE-II PHASE SEPARATOR



ELECTROSTATIC SEPARATION OF ^3He–^4He LIQUIDS



SURFACE TENSION SEPARATION OF ^3He–^4He LIQUIDS



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SPACE COOLER RESEARCH
ACCOMPLISHMENTS

- NEW PROGRAM INITIATED IN FY 88
- FORMULATED A COHERENT MULTICENTER NASA PROGRAM TO ADDRESS SPACE SCIENCE NEEDS
- CONCEIVED SEVERAL INNOVATIVE APPROACHES FOR SUBKELVIN APPLICATIONS

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SENSORS RESEARCH AND TECHNOLOGY
KEY POINTS OF CONTACT

	POINT OF CONTACT	LOCATION
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PASSIVE NON-COHERENT SENSING	C. McCREIGHT	AMES RESEARCH CENTER (415) 694-6549
ACTIVE SENSING	F. ALLARIO	LANGLEY RESEARCH CENTER (804) 865-3601
SPACE COOLER TECHNOLOGY	S. CASTLES	GODDARD SPACE FLIGHT CENTER (301) 286-8986

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SENSOR RESEARCH AND TECHNOLOGY
FUTURE PLANS

- IMPLEMENTATION OF THE CSTI SCIENCE SENSOR PROGRAM
- IDENTIFY SCIENCE SENSOR NEEDS DRIVEN BY FUTURE PROGRAMS
  - ⇨ PATHFINDER - PLANETARY AND LUNAR SURFACE EXPLORATION
  - ⇨ GLOBAL CHANGE TECHNOLOGY
- IDENTIFY OPPORTUNITIES CREATED BY NEW TECHNOLOGIES
  - ⇨ OPTICS
  - ⇨ PHOTONICS
  - ⇨ HIGH T_C SUPERCONDUCTIVITY